NEW DEVELOPMENTS FOR ACHIEVING ENVIRONMENTALLY FRIENDLY SINTER PRODUCTION - EPOSINT & MEROS®[1]

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Abstract

Environmental aspects are increasingly gaining importance in the design and operation of sinter plants. Siemens VAI has developed new technologies to reduce environmental impacts to an absolute minimum. With the Selective Waste Gas Recirculation system as a primary environmental measure, offgas generated during sintering is substantially reduced whilst part of the waste heat of the recycled gas portion is used. However, secondary measures are also necessary to meet today's and future environmental regulations. With MEROS® (Maximized Emission Reduction Of Sintering) as the latest state–of-the-art dry gas cleaning technology, sinter plant operators can look towards a bright future in respect to emission levels. The Selective Waste Gas Recirculation (eposint – environmental process optimized sintering) - jointly developed by Siemens VAI and voestalpine at voestalpine's plant in Linz/Austria - made it possible to avoid any additional environmental impacts when increasing the sinter capacity by 30% (by elongating the sintering machine). This was a precondition for local authorities to approve the expansion project. The implementation of Selective Waste Gas Recirculation resulted in lower absolute emissions of SOx and NOx. Furthermore, dioxin and mercury concentrations in the offgas were significantly reduced. In addition, specific coke consumption was also reduced.

Key words: Eposint; MEROS; Selective waste gas recirculation; Dry sinter gas cleaning

DESENVOLVIMENTOS NA TECNOLOGIA DE SINTERIZAÇÃO OBJETIVANDO PRODUÇÃO SUSTENTÁVEL - EPOSINT & MEROS®

Resumo

Aspectos do meio ambiente têm ganhado importância no projeto e operação de plantas de sinterização. SIEMENS VAI desenvolveu novas tecnologias para reduzir os impactos ambientais para valores mínimos. Como processo primário, a recirculação do gás gerado é utilizada, reduzindo substancialmente a quantidade de gás emitida, além de proporcionar a reutilização de parte do calor. Medidas secundárias se fazem necessárias como MEROS (Redução Maximizada da Emissão da Sinterização), considerada o estado da arte da tecnologia de limpeza de gás a seco. A recirculação de gás seletiva (eposint – processo ambiental de otimização da sinterização) – desenvolvida pela SIEMENS VAI e voestalpine in Linz/Áustria – tornou possível evitar qualquer aumento do impacto ambiental quando a capacidade da planta de sinter for aumentada para 30% (pelo alongamento da máquina de sinter). A implementação da Recirculação Seletiva de Gás resultou em baixa emissão de SOx e NOx, além de reduzir a concentração de dioxina e mercúrio no gás de topo. Quando aplicada a Recirculação Seletiva de Gás a uma planta existente, a emissão pode ser reduzida a aproximadamente 30 % sem modificação nos fatores de produção.

Palavras-chave: Eposint; MEROS; Meio-ambiente; Recirculação de gás seletiva; Limpeza de gás a seco.

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Eposint - Selective waste gas recirculation

Process description:

The air sucked through the sintering bed provides the oxygen required for the combustion of the fuel that is added to the raw mix and which accelerates the flame front through the sinter bed. This air volume is considerably higher than required for the complete combustion of the fuel in order to allow a high velocity of the flame front. Sinter waste gas therefore typically contains approximately 12–13% residual oxygen, which is sufficient for recirculation to the sintering process after the addition of a small amount of supplementary air. This kind of gas recirculation basically leads to the following major advantages:

- Significantly reduced waste-gas volume per sinter unit, thus reducing the investment and operation cost of waste-gas cleaning. This aspect is becoming increasingly important in connection with ever stricter limit values being imposed for fine dust, heavy metals, dioxins, SO_x, NO_x, HCl and HF.
- Reduced fuel consumption as a result of waste-heat utilization and CO post-combustion.
- Cost-effective solution for reusing existing sinter-plant equipment for a plant-capacity expansion by extending the length and/or width of the sinter strand.

In a joint cooperation project between the Austrian steel producer voestalpine Stahl and Siemens VAI (both in Linz/Austria), a new technology - referred to as eposint - was developed to enable the recirculation of sinter waste gas to the sinter strand. This system was started in March 2005 at Sinter Plant No. 5 of voestalpine Linz in connection with a project to expand the sintering capacity by extending the sinter strand length. No modifications were required at the existing suction system, which is comprised of a 3-field electrostatic precipitator, a process fan and an AIRFINE® wet-type gas-cleaning system supplied by Siemens VAI.

The eposint process is also suitable for installation in existing sinter plants without a capacity expansion, in order to reduce the waste-gas volume emitted from the stack. In new plants where this process is foreseen, the dimensioning of the total waste gas flow to the stack (collecting mains, fan, waste gas cleaning, stack diameter and height) can be fully optimized.

Process features and design aspects at voestalpine Stahl

A series of tests were initially conducted in Linz to determine which wind boxes of the sinter strand should be selected for an optimized gas recirculation with respect to the gas volumes and emission concentrations. As can be seen in Figure1-4, most emission values reach their peak or are at high levels in the burn-through zone of the sinter bed where the exhaust-gas temperature shows a steep increase.

Therefore, the wind boxes where the burn-through zone was at or near the bottom of the sinter bed were selected for waste-gas recirculation. It was also determined that the temperature of the recycled waste gas should be at approximately the same temperature level as the partial gas flow to be discharged through the stack in order to prevent the temperature from falling below the acid dew point in the waste gas ducts.

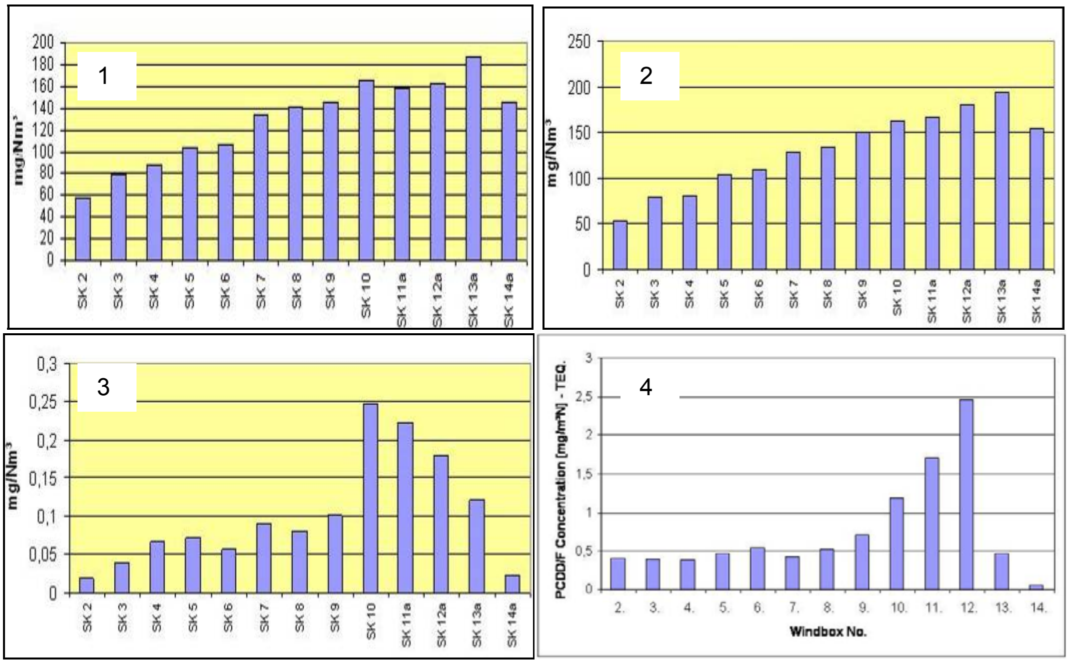


Figure 1: Emission trends of chloride, **Figure 2** potassium, **Figure 3** mercury and **Figure 4** dioxin from the sinter strand wind boxes

In comparison to other available sinter waste-gas recirculation processes where a partial gas flow from the total waste gas volume is withdrawn and recycled to the sintering process, in the eposint process the gas flow for recirculation purposes is only taken from selected wind boxes in the area of the waste gas temperature increase. At voestalpine Stahl this zone is located approximately in the third quarter along the sintering strand at the wind boxes 11–16 on the new extended sinter machine. **Figure 5** shows a schematic diagram of the eposint process at voestalpine Stahl. A second suction fan (waste gas recirculation fan) was installed parallel to the existing process fan to ensure the necessary suction pressure required for the sintering process. Its function is to exhaust the gases from the wind boxes where the temperature increases and to recycle it to the sinter strand.

Depending on the composition of the sinter mix and other operational conditions, the area of the temperature increase along the sinter strand varies. Therefore, in order to ensure an optimized gas recirculation with respect to the burn-through curve and the concentration of dust and pollutants in the waste gas stream, the offgas flow through the individual wind boxes can be independently directed either to the stack or back to the sinter strand for recirculation purposes **(Figure 6)**. This unique feature enables optimum response to varying operational conditions and is thus a decisive factor for the high degree of flexibility of the eposint process.

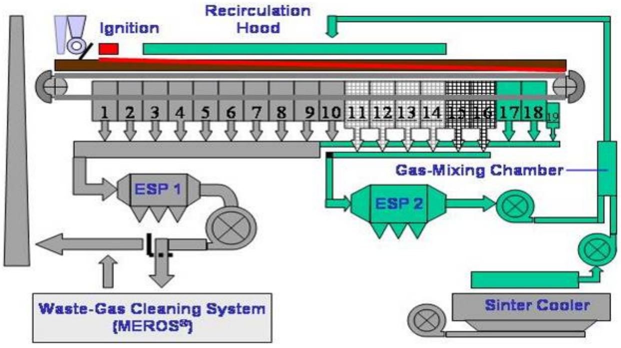


Figure 5: Schematic diagram of the eposint - selective waste gas recirculation
Figure 6: Wind box 11-16 are single switchable to optimize process conditions

Oxygen enrichment of the recycled gas at voestalpine Stahl is achieved by adding hot exhaust air from the cooler (fresh ambient air could also have been used). The cooling area of the existing circular dip-rail cooler was increased to accommodate the higher sintering plant capacity. Moreover, the cooling strand was partially covered to reduce particle emissions to the environment. This installation was thus highly effective for the extraction of hot air from the cooler for oxygen-enrichment purposes, which also contributed to a reduction in the sintering coke consumption.

After passing through a gas-mixing chamber, the waste gas is conveyed to the recirculation hood above the sinter strand. As a special feature of the eposint process, the sintering strand is not fully enclosed by the hood structure. It terminates at the side of the pallets where a non-contact, narrow-gap labyrinth seal prevents recycled waste gas and dust from escaping from the enclosure. This provides a high degree of safety against CO gas escape to the surroundings due to the prevailing low negative pressure. With this solution, only minor amounts of secondary air are drawn into the system. Furthermore, the pallet wheels are not exposed to dust—as with other recycling systems—thus preventing increased wear on moving parts.

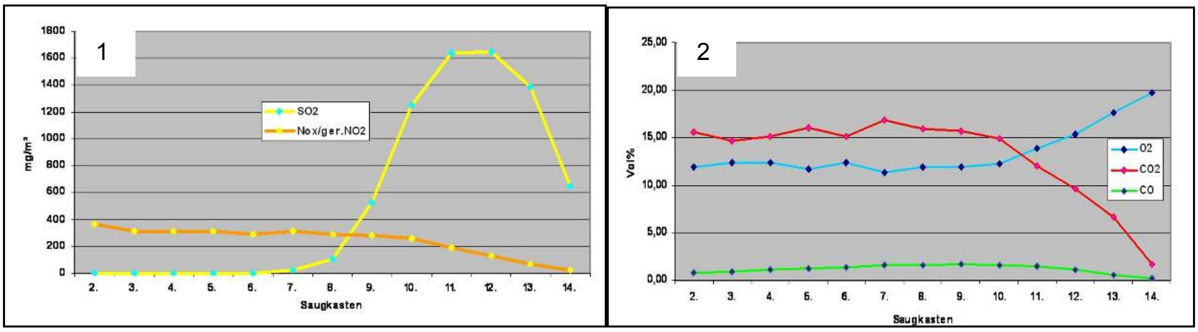
In addition to the system-pressure control to avoid gas and dust escape, bypass lines installed between the hood and the process fan are connected to a CO warning system. Therefore, if the pressure difference within the hood approaches zero in the unlikely event of failure of the pressure-control system or for any other reasons, the bypass lines are opened and the gas is directly drawn into the waste-gas collecting mains. This prevents any gas containing CO from escaping to the surroundings.

The recycle-gas hood does not extend to the end of the sinter strand in the eposint process. This allows fresh air to be drawn through the sinter bed in the area of the last few wind boxes which cools the upper sinter layer more efficiently. The improved accessibility of the open pallets offers additional advantages for maintenance work.

Emission aspects

Since the eposint system is optimized in accordance with the typical concentration curves of the major gaseous and particulate air pollutants, specific emissions are considerably reduced in comparison to other waste gas recirculation processes **(Figure 7)**. Dust and particle-bound heavy metals are efficiently separated in a downstream electrostatic precipitator. The treatment of this partial waste-gas flow with high concentrations of dust and pollutants and the subsequent reduction of the pollutant load (high concentrations of heavy metals, alkalis, chlorides, etc. in the dust) in the partial flow discharged to the stack is an important feature of the eposint process.It was proven that the concentration of SO_2 is highest in the area of the temperature rise along the sinter strand. eposint exhausts and completely recycles this highly enriched gas to the sinter strand. Following the constant sulfur combustion ratio, more sulfur is bound in the sinter itself.

Contrary to conventional waste gas recirculation processes with non-selective gas withdrawal, the eposint process emits less SO_2 to the stack while more is bound in the sinter and subsequently discharged from the sintering machine. Sulfur distribution (gas and sinter) is mainly dependent on sinter basicity and fuel amount/quality. At voestalpine Linz this results in unchanged SO_2 concentrations to the stack with and without eposint, but almost 30% reduced specific SO_2 emissions per ton of produced sinter.



Figures 7: Emission concentration trends of SO_2 and NO_x (1) CO_2 and CO (2).

Dioxins/furans entering the sinter bed via the recycled waste gas are effectively destroyed as they pass through the flame front due to the prevailing high-temperature conditions. Their concentration in the partial flow to the stack is reduced considerably. The CO contained in the waste gas recycled to the sinter strand is also combusted in the flame front. The concentration of CO in the waste gas exhausted from the sinter bed remains constant due to the equilibrium between C, O_2, CO_2 and CO in the flame front **(Figure 7).** The concentration of NO_x in the recirculation stream prevents NO_x from reforming, because the partial pressure of NO_x is primarily dependent on the conditions prevailing in the flame front and only to a negligible extent on the NO_x contained in the recycled waste gas. The NO_x concentration remains practically unchanged compared to an operating mode without waste-gas recirculation. Thus, the specific NO_x emission per ton of sinter is significantly reduced. As confirmed under actual operating conditions at voestalpine Stahl, fuel savings of 2–5 kg/t of sinter are achieved as a result of the higher temperature of the recycled waste gas and its inherent CO content which generates heat energy upon combustion.

Results of eposint at voestalpine Stahl

The extended sinter machine was started up on March 28, 2005 and the gas-recirculation system one week later. The production figures after start-up can be seen in **Table 1**. The target output was achieved within less than two months after resumption of sinter plant operation. After more than one year of operation it was verified that the eposint process had no significant influence on the specific sinter productivity or on the sinter quality in comparison to before.

Table 1: Sinter production data before and after plant expansion and installation of eposint process

	Before modernization	**With eposint**
Sinter strand speed (m/min)	1.6–1.7	2.2–2.4
Sinter production (t/24h)	6350	8300 (8500)
Productivity ($t/m^2/24h$)	37.6	36.6 (38.3)
Coke consumption (kg/t Sinter)	45	41
Ignition gas consumption (MJ/t Sinter)	50	40
Electrical energy consumption incl. Airfine© gas cleaning (kWh/t Sinter)	40	40
Dust concentration (mg/Nm³ // g/t_{Sint})	46 // 104	38 // 66
SO_2 concentration (mg/Nm³ // g/t_{Sint})	420 // 952	390 // 677
NO_x concentration (mg/Nm³ // g/t_{Sint})	240 // 544	240 // 416
HF concentration (mg/Nm³ // g/t_{Sint})	1.0 // 2.3	0.6 // 1.0
Sinter grain size 4–10 mm (%)	32–34	33–36
ISO tumbler test ISO+6.3mm (%)	78–82	79–82
RDI < 3.15 mm) in %	18–20	19–20
Reducibility R/dt(40)	0,9–1,0	0,95–1,05
FeO (%)	6-8	7-8.5

Due to the high temperature during sintering, components with a noticeable vapor pressure like alkali halides, volatile organic compounds (VOC's) and heavy metal chlorides (e.g. mercury, lead) are volatilized. Re-condensation of these components in the offgas system of the sinter machine results in a high fraction of PM 10/2.5 in the dust emission of sinter plants. Considerable amounts of the sulfur contained in the sinter feed leaves with the offgas in form of the acid gases SO_2 and SO_3 (sulphur oxides). Other acid gases contained in the offgas are HCl and HF.

In the past, the dust emission limit for sinter plants was 50 mg/Nm³. In the new TA-Luft 2002 (Clean Air Act Germany, which is adhered to by most European States), the general dust emission limit has been reduced to 20 mg/Nm³. However, an exception has been made for existing sinter plants. Typical offgas flows of sinter machines lie in the range of 500.000 to 2.000.000 Nm³ per hour. Annual operation hours above 8400, together with the high fraction of PM 10/2.5 in the emitted dust, result in PM 10/2.5 emissions for a typical sinter plant operated in compliance with actual dust emission limits of 200 – 800 tons per year. In Linz, a mid-size industrial town in Upper Austria, the sinter plant of the integrated steel mill accounted for 14% of the overall PM 10 emissions in 2001. Reduction of PM10/2.5 emissions is therefore a major challenge for steel mills.

Due to the high emission potential of sinter plants, environmental authorities in Europe are extending their focus to emission compounds other than particulate matter, namely SO_2, dioxine/furane (PCDD/F), heavy metals and nitrogen oxides (NO_x).Therefore, at the same time as the sinter-strand extension in Linz and the eposint installation, a decision was made to replace the previous VAI-built wet-type gas-cleaning system (AIRFINE®) with a dry-type solution in order to fulfill the stricter municipal environmental emission regulations which resulted from the 18 meter sinter strand extension in 2005. The decision to install a MEROS plant in Linz is based on the successful results achieved in a series of test campaigns conducted in a 90,000 Am³ per hour demonstration plant from May 2005 to July 2007, during which time the technical and economical advantages of this process were proven. The new MEROS plant is capable of treating more than 1,000,000 Am³ of sinter gas per hour and is scheduled for start-up in August 2007. With the start-up of the industrial MEROS plant, voestalpine will not only meet the environmental emission regulations of today, but also those of the future.

MEROS process description

MEROS is a highly efficient dry-type gas-cleaning process developed by VAI for the treatment of sinter and pellet plant offgas (**Figure 8**). The technology is based on the following process steps:

- Adsorbents injection into the sinter offgas stream
- Offgas conditioning in conditioning reactor
- Offgas de-dusting in a bag filter
- Recycling of dust to offgas stream
- Exhaustion of sinter offgas from MEROS system with booster fan

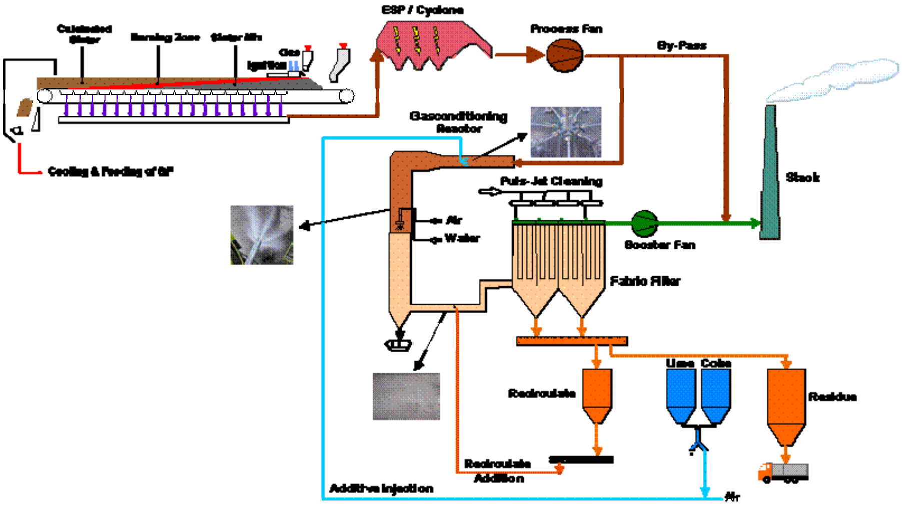


Figure 8: Process flow sheet MEROS process

Adsorbent injection

In the first step of the MEROS Process, adsorbents such as specially prepared lignite coke or activated carbon powders as well as desulphurization agents (sodium bicarbonate or hydrated lime) are injected into the sinter offgas stream at a high injection velocity - exceeding 30 m/s - in the counter-current flow direction. A distributor unit comprised of several injection lances installed along the circumference of the offgas duct ensures a uniform, homogeneous injection of the adsorbents (**Figure 9 and 10**).

The carbon adsorbent physically binds (i.e. adsorbs) the heavy metals, organic complexes (dioxins/furans and VOC's - volatile organic compounds) and sulfur compounds due to its highly porous structure.

Figure 9: Additive distributor

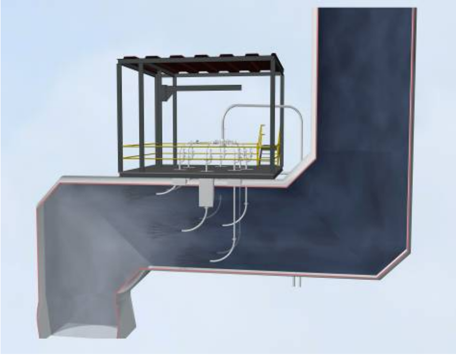


Figure 10: Additive injection

The injection of specific desulphurization agents into the offgas stream promotes $DeSO_x$ reactions as well as reactions with other acid gases e.g. HCl. The relative merits and disadvantages of employing either sodium bicarbonate or hydrated lime for desulphurization purposes are compared in **Table 2**. It was shown that approximately 50% of the gas-cleaning activities in the MEROS process already take place during the adsorbent-injection step.

Offgas conditioning (only if hydrated lime is used for $DeSO_x$)

In a specially designed conditioning reactor, cooling and moisturizing of the sinter offgas then takes place with the use of highly efficient dual-flow (water/compressed air) injection nozzles, which uniformly disperse mist droplets across the full reactor diameter (**Figure 11 and 12**).

Figure 11: Dual flow water mist

Figure 12: Water injection lances

The offgas temperature is cooled to 90–100 °C for efficient desulphurization conditions and to avoid potential damage to the downstream fabric filter bags. The moisturized offgas accelerates the chemical reactions for binding and removing sulfur dioxide and other acidic gas components present in the offgas stream. The water-injection rate is controlled by inlet/outlet temperature monitors in such a way that all of the injected water into the system evaporates without excess water droplets remaining. Virtually all of the dust particles (primary dust, additives and reaction products) flow to the fabric filter with the offgas stream. Minor amounts of separated material (e.g., agglomerated particles) are removed at the bottom of the conditioning reactor by a conveyor system.

Offgas dedusting in a bag filter

After exiting the conditioning reactor, the dust-laden offgas then flows to a pulse-jet-type bag filter comprised of high-performance fabric materials supported by a filter cage. In the filter raw-gas chamber, the gas velocity is reduced. The dust concentration and temperature are carefully controlled to avoid any possibility of hot spots arising due to carbon annealing. This extremely fine dust consists of primary sinter dust, organic compounds, additives and reaction products which, due to their high alkali content, are relatively sticky.

To avoid dust penetration and clogging within the fabric material, the fabric is coated with a chemical and temperature-resistant membrane. The dust particles which settle on the surface of the fabric membrane surface gradually accrue to a filter cake which is periodically removed from the fabric by a powerful reverse-air impulse. The filter cake drops from the cloth surface into a dust-collection hopper.

Recycling of dust to offgas stream

In order to enhance the sinter offgas-cleaning efficiency and to significantly reduce additive costs, most of the dust separated in the bag filter is recycled to the gas stream just after the conditioning reactor. This dust (re-circulates) consists of primary dust, carbon/coke, un-reacted $DeSO_x$ reagents as well as reaction products such as gypsum or sodium sulfate. Unreacted sorbents once again come into contact with the offgas, thus increasing the sorbent efficiency and reducing the costs for consumables.

This procedure also has an additional technological background. Due to the high re-circulate concentration (~15 g/Nm^3 gas), this dust quickly collects on the fabric filter cloth as a filter cake which promotes the further removal of residual mercury, dioxins, furans and other organic compounds in the offgas stream. To avoid possible condensation, all conveyors and bins which come into contact with the recirculate are insulated and heated.

DeNOx, booster fan and clean gas duct

If required, NO_x emissions can be significantly reduced by installing a selective catalytic reduction (SCR-DeNOx) process either right before or after the booster fan. The booster fan exhausts the offgas from the gas cleaning system. Suction pressure and emission levels are carefully monitored to ensure that the prescribed emission values are maintained at all times. The clean gas leaves through a stack.

Additive and residue storage

The additives for adsorption (lignite/activated carbon) and desulphurization (lime/soda) are delivered by tank trucks and pneumatically fed to the additive storage silos. From there, the material is fed to the intermediate gravimetric dosage bins for further injection into the raw gas duct. A portion of the dust which collects in filter hoppers is not re-circulated to the MEROS process, but is removed from the system and conveyed to a residual bin. This is to compensate for the amount of fresh additives injected into the offgas stream. The residue is discharged to silo trucks for external environmentally friendly utilization.

Demonstration plant

Due to the specific situation of the sinter plant operation in Linz (e.g. domestic Styrian ore with high alkali and heavy metal concentration as well as the partial offgas recycling), a decision was made to verify the dry-type gas cleaning in a demonstration plant before installing the industrial scale plant **(Figure 13)**.

Figure 13: Demonstration plant at voestalpine

In a series of test campaigns which have been conducted since May 2005, the technical and economical feasibility of the MEROS process has been verified.
The unit's offgas treatment capacity of approx. 90,000 m³/h was large enough to accurately assess the offgas cleaning efficiency as well as to determine the necessary design and operational parameters for an industrial up-scaling.

Operation results

The cleaning efficiency of the MEROS process depends on a number of operating conditions such as the concentration of various components in the raw gas, gas temperature, conditioning temperature, additive quantities, quality and type, dust recirculation rate as well as bag filter material and bag cleaning procedure.

Desulphurization

Depending on the local requirements and conditions, two principal desulphurization agents can be employed—either sodium bicarbonate or hydrated lime. A comparison of these two agents can be seen in **Table 2**.

Table 2: Comparison of sodium bicarbonate and hydrated lime for use as desulphurization agent

	Sodium bicarbonate	**Hydrated lime**
$DeSO_x$ degree	> 90% (if required)*	40–80% *
Stochiometric factor	1.1–1.4	2 - 4
Residuals	60–70%	100%
Reagent costs	140–210%	100%
Exit-gas temperature	= Inlet temperature	90–100 °C
$DeNO_x$(if required)	Less fuel for gas heating	More fuel for gas heating

* depending on additive quality, sinter gas temperature, conditioning temperature

- Sodium bicarbonate

The use of sodium bicarbonate is preferred when highest $DeSO_x$ degrees are required, if a $DeNO_x$ plant is necessary or where landfilling costs are high.

Acid neutralization with sodium bicarbonate involves a stage of thermal activation, i.e., when brought into contact with the hot offgas, the sodium bicarbonate rapidly converts into sodium carbonate with a high degree of porosity and specific surface area.

The conversion of sodium bicarbonate into "activated carbonate" through the contact with heat makes this material an excellent medium for the neutralization of acids (e.g., hydrochloric acid, sulfur dioxide, hydrofluoric acid) as well as for the adsorption of volatile heavy metals, dioxins and furans. Since sodium bicarbonate is quite hygroscopic and tends to stick if it is finely ground, the material is delivered as a coarse grain. To avoid clogging in the silo and dosing system, the material is ground in situ just before injection.

- Hydrated lime

The moisturized lime particles react with all acid gas components in the sinter offgas to form reaction products. It was verified that different hydrated lime products show major differences in efficiency for desulphurization. In addition to chemical composition and grain size, the specific surface of the lime is also a key factor. This lime surface should be as high as possible. Investigation and assessment of different agent products lead to an optimization of operation cost. The gas conditioning temperature is also a decisive factor for the desulphurization. The lower the gas temperature is adjusted in the conditioning reactor, the better the sulfur dioxide removal efficiency. Thus operation costs can be optimized as a result of improved stoichiometry of the lime **(Figure 14)**.

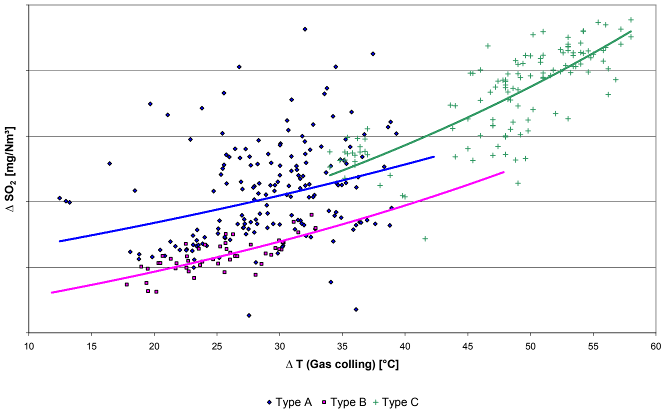


Figure 14: DeSOx efficiency with various hydrated lime types

Heavy metal and PCDD/F elimination

Heavy metals and compounds thereof with low vapor pressure, like mercury salts, cadmium or lead, are removed as particulates at the filter bags. Since the remaining clean gas dust content is extremely low, these parts of heavy metals easily comply with the current regulations. The gaseous portion of these pollutants and metallic mercury, which has a high vapor pressure, is removed by adsorption at lignite or activated carbon. It was proven that due to the high relative velocity during additive injection, approximately 50% of the adsorption is already achieved within the injection zone. The other 50% is eliminated while the gas passes through the additive-containing filter cake on the filter bag. This also applies for PCDD/F. Various adsorbents have been investigated in order to assess the efficiency for mercury (Hg) elimination from the offgas stream. Removal degrees of more than 95% were obtained either using lignite or with activated carbon injection.

Filter bags

A change of a complete set of filter bags is one of the major maintenance cost factors. In addition to the cost factor, an extremely low fine dust concentration of less than 10 mg/Nm³ also has to be ensured in the long term. In order to meet these objectives, attention must be paid to the type of filter bags used (base material, surface conditioning) as well as to the manufacturing procedure (sewing). The bags have to deal with submicron particulate matter, high humidity of the sinter gas (hydrolyse), acid gas compounds, high temperatures (up to 200 °C), high dust loads and high mechanical stress (frequent pulsing cycles).

Therefore, in the pre-selection of fabric filter material, different filter materials were investigated in the demonstration plant over more than 2 years.
Samples of used filter material were taken periodically for testing. The parameters included air permeability, infiltration of dust and tensile strength. After more than 16,000 operation hours, the results can be summarized as follows.

The dust concentration after the fabric filter remained clearly below 5 mg/Nm³. The air permeability of selected filter material types was only slightly reduced (pressure drop), which indicates that no major infiltration through the membrane took place. This is also confirmed by the visual microscope investigations where no noticeable dust deposition inside filter material could be detected. The tensile strength shows a substantial decline in both directions of the fabric material (warp and weft) for one type (expected life time ~ 3 years). For the other material type the drop in tensile strength was much less (extrapolated life time ~10 years).

Commercial plant

Subsequently, based on the comprehensive 2-year operation results from the demonstration plant, the up-scaling to industrial size (scale-up factor approx. 10:1) was carried out by the engineers. Project execution time was from March 2006 until August 2007 (start-up). Major plant data can be seen in **Table 3**.

Table 3: Main plant data and expected emission (reduction) levels

Design gas flow	620.000 Nm³/h	Dust	< 5 mg/Nm³
Raw gas temperature	120 – 160 °C (130 °C)	Hg removal	> 95 %
Pressure drop of plant	~ 3200 Pa	Pb, Cd removal	> 99%
No. of filter bags	4.760	HCl removal	> 90%
Filter area	~ 19.000 m²	HF removal	> 90%

Cooling water flow	8 – 30 m^3/h	PCDD/F	< 0,1 ng TEQ/Nm^3
Process temperature	90 – 100 °C	VOC condensable	> 99%
Dust recirculation	~ 10.000 kg/h	SO2 removal	~ 200 mg/Nm^3
Hydrated lime injection	~ 330 kg/h		
Lignite injection	~ 60 kg/h		

Conclusion

In connection with a sinter plant capacity-expansion project carried out at voestalpine Stahl, the new eposint selective waste gas recirculation process was simultaneously implemented. Since the restart of the expanded sinter plant on March 28, 2005, the specific amounts of dust and pollutants, including SO$_2$, NO$_x$, dioxins and heavy metals, alkalis and chlorides, have been considerably reduced in comparison to the previous sinter plant operation. Furthermore, with consideration to the recirculation of hot waste gas from the sinter plant mixed with hot air from the sinter cooler, fuel savings of 2–5 kg coke breeze per ton of sinter were achieved in addition to further savings of coke oven gas for ignition.

MEROS technology represents a new milestone in the treatment of sinter offgas. As confirmed at the demonstration plant at voestalpine Linz in a more than 2 years of continuous operation, the removal efficiency for dust, heavy metals, acid and organic compounds from a sinter offgas stream using this process is so far unsurpassed in the industry. With the start-up of the MEROS plant scheduled for August 2007, voestalpine will not only be able to meet the environmental emission regulations of today, but also those of the future.

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References

1. A. Fleischanderl, T. Plattner, C. Lanzerstorfer, “Efficient Reduction of PM 10/2.5 emissions at Iron Ore Sinter Plants”, Proceedings, DustConf 2007, Maastricht, April 23-24, 2007.
2. A. Fleischanderl, “Improved dry-type gas-cleaning process for treatment of sinter offgas”, MPT International, 3/2006, pp. 36-40
3. H. Sigmund, “Die Feinstaub-Herausforderung für die Stahlindustrie, Gießereirundschau 53, 2006, pp. 146-148.
4. W. Hartig, R. Lin, “Comparison of Waste Gas Cleaning Systems for sinter plants of VDEh member works”, Korean-German New Steel Technology Symposium, July 4-5, 2005, pp. 1-22.
5. Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft - TA Luft) vom 24. Juli 2002. Heymanns Köln Berlin Bonn München, 2002, pp. 36f, 90f.
6. S. Ellmer, E. Danninger, “Statuserhebung für das Jahr 2002 gemäß §8 Immissionsschutzgesetz-Luft (IG-L) BGBl.I Nr. 115/1997 i.d.F. BGBl.I Nr. 101/2002 – Grenzwertüberschreitungen der Luftschadstoffe Schwebstaub und PM 10“, Amt der OÖ Landesregierung, 2002, pp. 57-58.